SURFACE HYDROLOGICAL CALCULATIONS
FOR THE
YELLOW CAT MINE PROJECT

Prepared for

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1.0 CLIMATOLOGICAL PARAMETERS

Climatological parameters for the Yellow Cat project area are summarized in Table A-1. These estimates were taken from published records available from the U.S. Weather Bureau, Department of the Interior, and the Utah State Climatologists Office (listed in the references to this appendix).

2.0 STORM EVENTS

In accordance with the State of Utah, Department of Health, runoff from storm events with a 25-year recurrence interval were utilized for the design of the diversion and collection facilities around and within the perimeter of the heap dumps, respectively. Precipitation totals for the various durations of the 25-year storm event are presented in Table A-2.

3.0 RUNOFF

In Figure A-1, the major basin and sub-basins tributary to the project site are delineated. The basin watersheds are comprised of steep, mountainous slopes in the upper reaches, ranging to alluvial fan slopes in the lower reaches. These slopes range from approximately 35 percent to 4 percent, respectively.

Conveyance features such as roadways, culverts, and other such structures which may divert runoff away from the project site were assumed to not interrupt the basin configuration or divert runoff from the site for conservancy of design.

TABLE A-1

ESTIMATED CLIMATOLOGICAL PARAMETERS FOR YELLOW CAT PROJECT

Average annual precipitation	10.0 inches
Average annual "Class A" pan evaporation	64.0 inches
Average annual lake evaporation	44.5 inches
Pan coefficient	0.70
Average May-October percent of annual evaporation	80.2%
Average May-October lake evaporation	35.7 inches

TABLE A-2

25-YEAR RECURRENCE INTERVAL PRECIPITATION-DURATION SUMMARY*

Duration (hrs)	Total Precipitation (inches)
0.083	0.29
0.17	0.45
0.25	0.57
0.50	0.79
1.00	1.00
2.00	1.10
3.00	1.20
6.00	1.43
12.00	1.76
24.00	2.05

* The method used for determining total precipitation is described in Miller, et al, 1973.

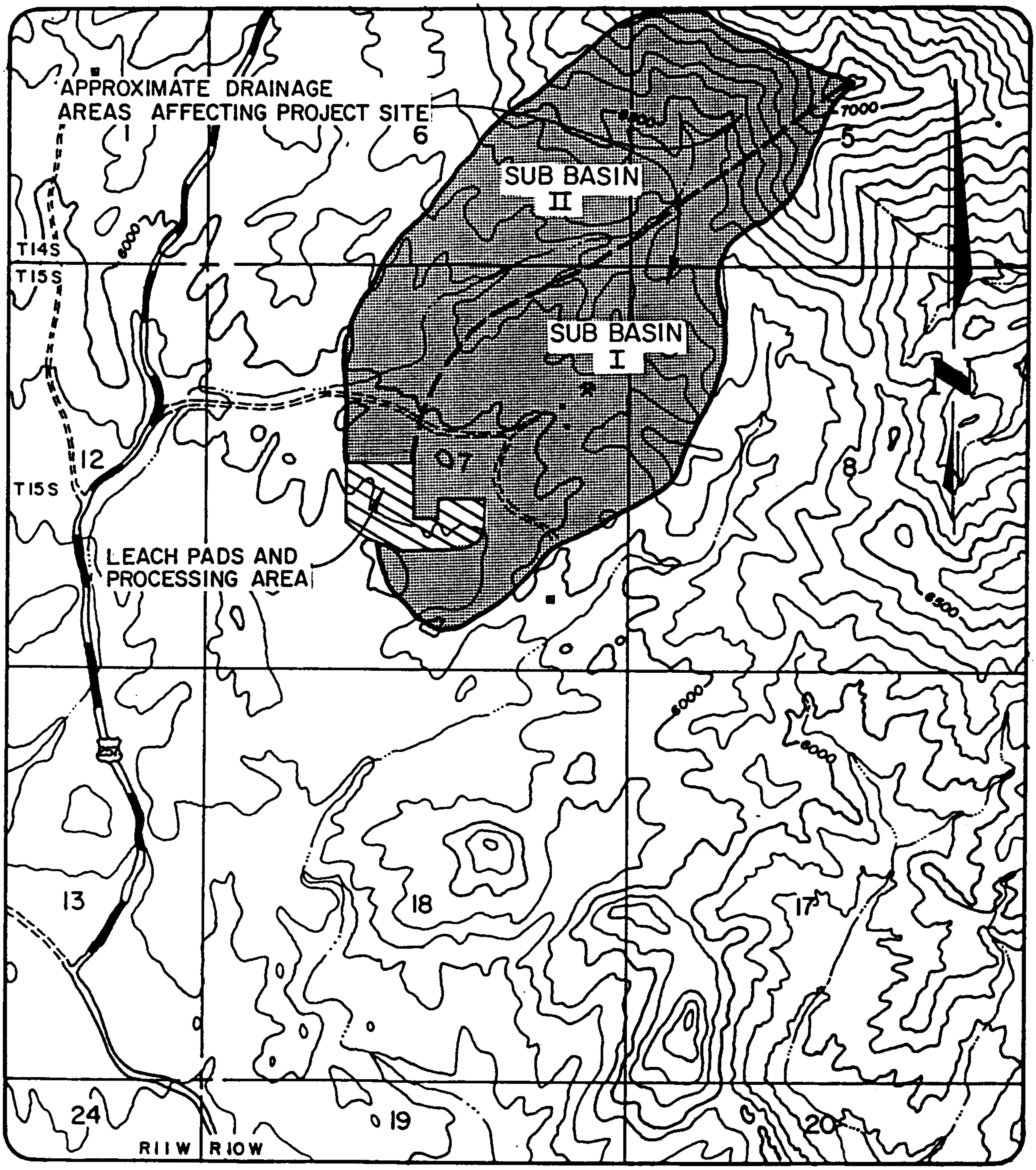

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FIGURE A.1

PROJECT SITE WATERSHED

3.1 Watershed Characteristics

Characteristics of the watershed applicable to runoff computations were based upon data obtained from the following sources:

a) Soil Conservation Service (SCS) soil maps of the site area;
b) Topographic maps of the site area; and
c) Field investigations and observations of the site.

For each sub-basin, a "Type B" hydrological soil group was chosen for the runoff computations. This choice was based on 25 percent vegetation cover and a soil of moderately-fine to moderately-coarse texture with a slow infiltration rate to be conservative. An SCS curve number (CN) equal to 79 was used to represent these conditions.

Basin specific characteristics are given as follows.

Sub-Basin	Area (mi^2)	Elevation Difference (ft)	Stream Length (mi)
1	0.45	1,338	1.61
2	0.50	1,318	1.70

3.2 Runoff Estimation Methods

Storm runoff estimates for each sub-basin were determined by use of the appropriate SCS peak rate discharge curves for small watersheds (T.R. NO55) applicable to the terrain topography, curve number, and storm precipitation type for a 24-hour storm duration.

Maximum discharges were determined to be 110 cfs for sub-basin 1 and 115 cfs for sub-basin 2. Diversion channels for each sub-basin were then sized to convey these peak flow rates.

3.3 Diversion Channels

The diversion channel for runoff from sub-basin 1 conveys approximately 110 cfs around the easterly perimeter of the heap dump areas for outlet ultimately just south of the project site into a natural drainage course. Storage of the runoff could be accomplished without difficulty at this location for use in part as leaching solution. At those locations where the channelized flow must pass beneath the haul road, corrugated metal pipe structures will be utilized to convey the flow.

Approximately 115 cfs of storm water runoff from sub-basin 2 is conveyed via channel flow around the westerly perimeter of the heap dump areas to an ultimate outlet point, into a natural drainage course located at the southwest corner of the project site.

Typical cross sections of the diversion ditches for sub-basins 1 and 2 are illustrated in Figures A-2 and A-3, respectively. In Tables A-3 and A-4 are listed the hydraulic design parameters used for the sizing of the trapezoidal ditch sections. The design parameters listed are based upon Manning's equation and are representative of an anticipated minimum slope of 0.50 ft/ft and those specified maximum slopes corresponding to a maximum velocity of 5 fps, for erosion considerations.

In the event that construction of the channel in certain locations requires that slopes be in excess of the slopes corresponding to the maximum velocity of 5 fps for a specific channel bottom width, the channel will be lined with minimum 24-inch mean diameter riprap with a mean dimension ratio less than 2.

Alternatively, riprapped slope drop chutes can be constructed in order to step-down the maximum allowable slope in accordance with the existing ground slope. A detail of a slope drop chute for b equal to 16 ft and Q equal to 115 cfs is given in Figure A-4, as are the hydraulic parameters used for its sizing. This detail is applicable to either diversion channel where slopes in excess of 2 percent are anticipated for a channel of 16 ft bottom width and 2:1 side slopes. Riprap of the same specifications as stated before will be required for a distance of 12 ft upstream of the chute, along the entire length of the chute, and for a distance of 15 ft downstream of the chute.

Culverts have been sized to convey a maximum flow of 115 cfs and are therefore applicable to both diversion channels. A summary of the hydraulic parameters used to size two 58 inch x 36 inch CMP pipe arches, or alternatively three 36-inch diameter CMP culverts, to pass this flow are presented in Table A-5. Culverts will be required at all haul road crossings and other locations where channel excavation is not possible.

TABLE A-3 CHANNEL CHARACTERISTICS (BASIN I)*

Flow Rate (cfs)	Longitudinal Slope ** (%)	Bottom Width (ft)	Depth of Flow (ft)	Average Velocity (fps)
110	2.00**	16	1.25	5
110	1.50**	10	1.70	5
110	1.45**	8	1.90	5
110	1.30**	6	2.20	5
110	0.40	16	1.85	3.13
110	0.40	10	2.4	3.20
110	0.40	8	2.6	3.30
110	0.40	6	2.8	3.40

* n = 0.04, side slopes = 2H:1V, V_{max} = 5 fps

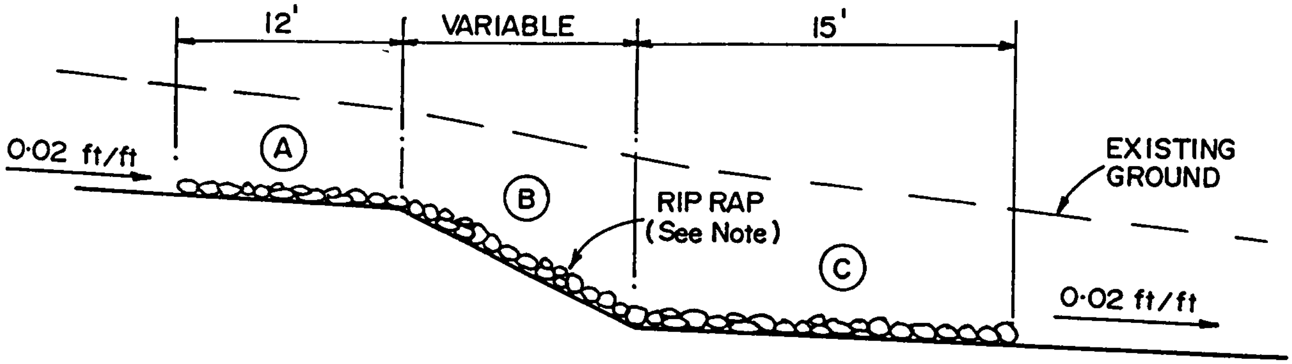
** Channel slopes exceeding those maximums specified herein will result in velocities in excess of 5 fps and will require erosion control protection. Otherwise, maximum longitudinal slopes given should be used in conjunction with sloped drop chutes detailed in Figure A-4.

TABLE A-4 DIVERSION CHANNEL CHARACTERISTICS (BASIN II)*

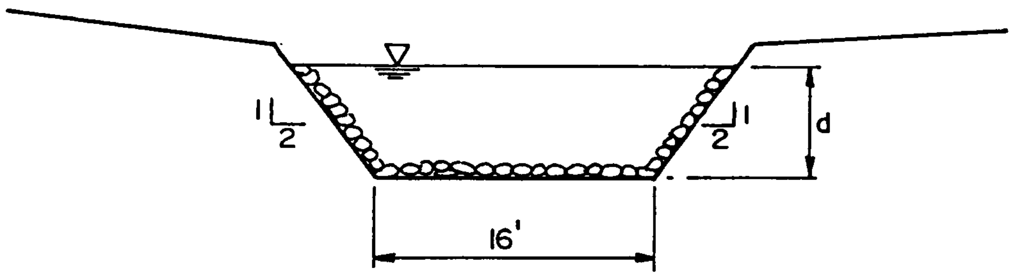
Flow Rate (cfs)	Longitudinal Slope ** (%)	Bottom Width (ft)	Depth of Flow (ft)	Average Velocity (fps)
115	2.00**	16	1.30	5
115	1.50**	10	1.75	5
115	1.45**	8	1.95	5
115	1.30**	6	2.25	5
115	0.40	16	1.90	3.06
115	0.40	10	2.45	3.15
115	0.40	8	2.65	3.26
115	0.40	6	2.90	3.35

* n = 0.04, side slopes = 2H:1V, V_{max} = 5 fps

** Channel slopes exceeding those maximums specified herein will result in velocities in excess of 5 fps and will require erosion control protection. Otherwise, maximum longitudinal slopes given should be used in conjunction with sloped drop chutes detailed in Figure A-4.



CHANNEL PROFILE



CHANNEL CROSS SECTION (TYP.)

NOTE

RIP RAP TO BE MINIMUM 24" MEAN DIAMETER WITH DIMENSION RATIO LESS THAN 2

SLOPED DROP CHUTE HYDRAULIC PARAMETERS *	d	V	REMARKS
(A) CHUTE APPROACH	1·25	5·0	NORMAL DEPTH FLOW
	1·05	5·8	CRITICAL FLOW
(B) CHUTE	0·50	12·9	SUPERCRITICAL FLOW
(C) APRON	2·8	1·9	HYDRAULIC JUMP (ENERGY DISSIPATION)

* Q_{max} = 115 CFS
n = 0·04

PROJECT NO.	PREPARED BY:	FIGURE A-4
FUNCTION NO.	STEFFEN ROBERTSON & KIRSTEN Consulting Engineers	SLOPED DROP CHUTE DETAIL
REVISION NO.		

TABLE A-5 CORRUGATED METAL PIPE CULVERT CHARACTERISTICS (BASINS 1 AND 2)

Culvert Size and Type	Flow Rate (cfs)	Headwater (ft)	Tailwater (ft)	Culvert Slope (ft/ft)	Culvert Control Condition
Two 58 inch x 36 inch pipe arch	115	2.9	2.3	0.005	Outlet (barrel)
↓	115	2.7	2.3	0.010	↓
↓	115	2.6	2.3	0.015	↓
↓	115	2.4	2.3	0.020	↓
Three 36-inch diameter	115	3.5	2.5	0.005	↓
↓	115	3.3	2.5	0.01	↓
↓	115	3.2	2.5	0.015	↓
↓	115	3.0	2.5	0.020	↓

Supplementary Pipe Data

1) $n = 0.02$

2) $K_e = 0.5$ (end section conforming to slope)

3) $L = 32$ ft (culvert length)

4) $T.W. = \frac{dn + dc}{2}$

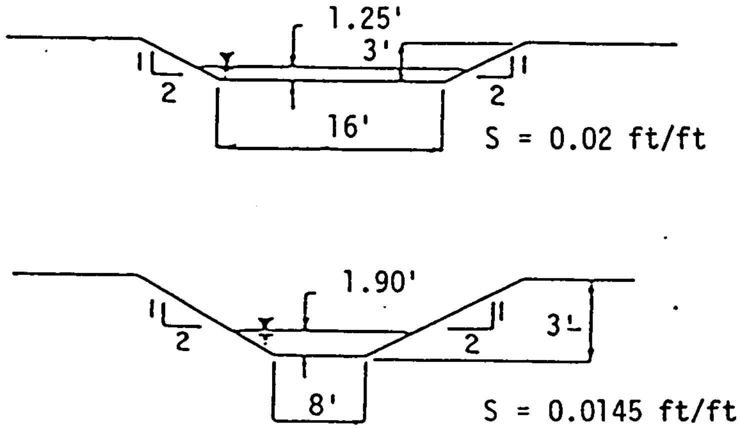
3.4 Runoff in Processing Areas and Mine Areas

All storm water runoff generated from the heap leach dump/processing areas will be conveyed by collection ditches and berms to the barren solution pond. This pond has been sized to accommodate, in addition to the processing solutions, runoff from the 25-year, 24-hour storm event. The collection ditches are discussed in greater detail in Section 4.0.

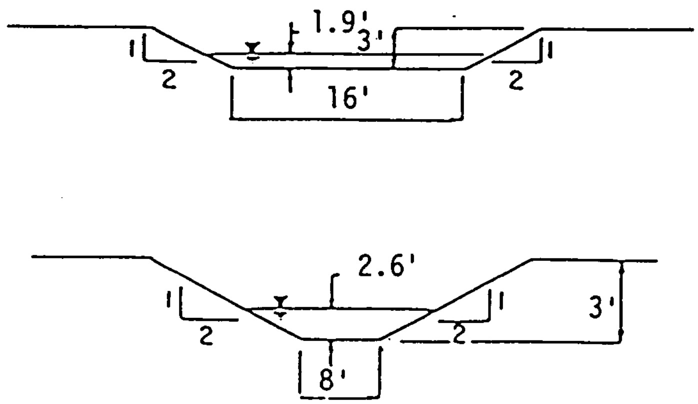
Runoff within the mined areas will be contained within the mine pit and collected within sumps. The runoff will then be pumped back for processing/operational uses.

3.5 Hydrologic Structures at Reclamation

At the time of reclamation, it is anticipated that the diversion ditches will remain in place and be vegetated. Culverts will be removed and replaced with an equivalent reach of excavated channel. In those areas where excavation is not possible or practical, the diversion ditches will be rerouted appropriately.



Typical Sections for 2.0% and 1.45% Slopes (V_{max} = 5 fps)



Typical Sections for 0.4% Slope

Note: b = 8 ft and 16 ft

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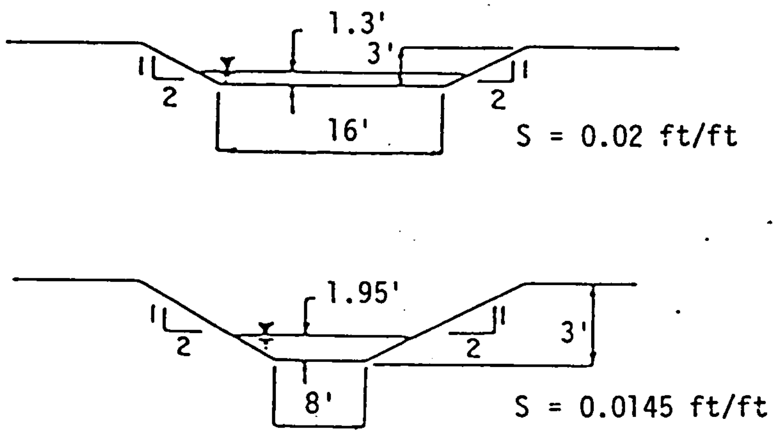
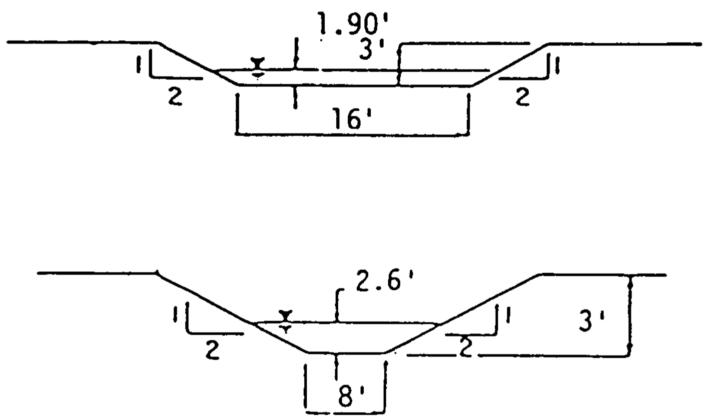
FIGURE A-2

DIVERSION CHANNEL
CROSS SECTIONS (BASIN I)



Typical Sections for 2.0% and 1.45% Slope (V_{max} = 5 fps)



Typical Sections for 0.4% Slope

Note: b = 8 ft and 16 ft

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FIGURE A-3

DIVERSION CHANNEL

CROSS SECTIONS (BASIN 2)

4.0 COLLECTION DITCHES

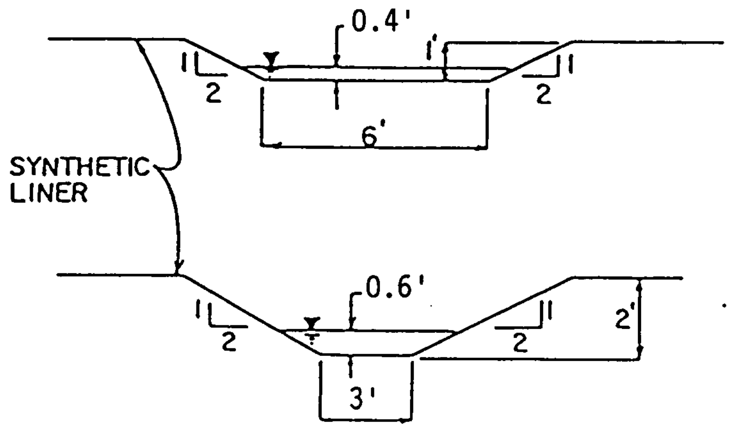
The collection ditches within the perimeter of each of the three heaps were designed for storm runoff using the rational method for runoff (Q = CiA). A coefficient of runoff (C) equal to 0.90 was used to represent the heap above an impermeable liner. For each 425 ft x 650 ft heap, an area (A) of 6.34 acres (0.010 mi^2) was used. A maximum intensity value (i) equal to 3.48 inches/hr for the 25-year storm of 5-minute duration was used, since the time of concentration can be assumed to be equal to approximately the duration time for basins of this size. A peak flow value of approximately 19.9 cfs was determined for each heap dump for the 5-minute storm duration. Including the proposed 500 gpm (1.1 cfs) leaching solution application rate, the collection ditches are required, at minimum, to convey approximately 21.0 cfs.

Typical cross sections of the collection ditches are shown in Figure A-5 for two different width trapizoidal ditches. In Table A-6, the hydraulic parameters used for the sizing of the trapezoidal ditches (based on Manning's Equation) are presented. These parameters are representative of anticipated minimum and maximum ditch slopes within the perimeter of the heap dump pads. Since the ditches are to be lined with a synthetic material, velocities up to approximately 8 fps are acceptable. However, sand bags or check dams are recommended to reduce velocities along steep ditch sections and, as well, at bends along the ditch.

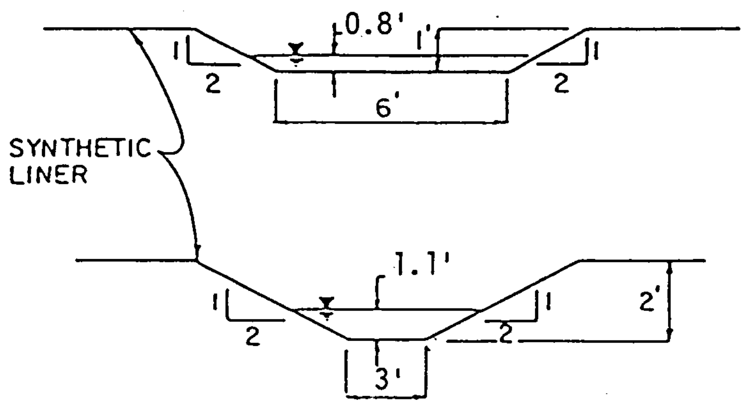
TABLE A-6

COLLECTION DITCH CHARACTERISTICS

Flow Rate (cfs)	Longitudinal Slope (%)	Side Slopes (vert:horiz)	Bottom Width (ft)	Manning's "n"	Depth of Flow (ft)	Average Velocity (fps)
21	4.0	1:2	3	0.02	0.6	8.7
21	4.0	1:2	6	0.02	0.4	7.4
21	0.4	1:2	3	0.02	1.1	3.8
21	0.4	1:2	6	0.02	0.8	3.5



Typical Sections for 4% Slope



Typical Sections for 0.4% Slope

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FIGURE A-5

COLLECTION DITCH

CROSS SECTION

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